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VX1

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(54) Coated valve seat

(57) A joined type valve seat has a coating layer of thickness of 10µm or less. The layer has a coefficient of thermal expansion of an intermediate value between the valve seat material and the cylinder head material. The surfaces of the valve seat contacting with the cylinder head are coated. Where the valve seat is made of Fe-base sintered alloy, the layer will have a coefficient of thermal expansion of 15×10^{-6} - 25×10^{-6} (1/K). Where the valve seat is made of Cu-base alloy, the layer will have a coefficient of thermal expansion of 18×10^{-6} - 27×10^{-6} (1/K). Where the seat is made of ceramics the layer will have a coefficient of thermal expansion of 10×10^{-6} - 20×10^{-6} (1/K).

The coating will be a pure metal or alloy layer (e.g. Cu, Ag, Ni).

The seat is joined to the cylinder head by welding.

The cylinder head is preferably aluminium alloy.

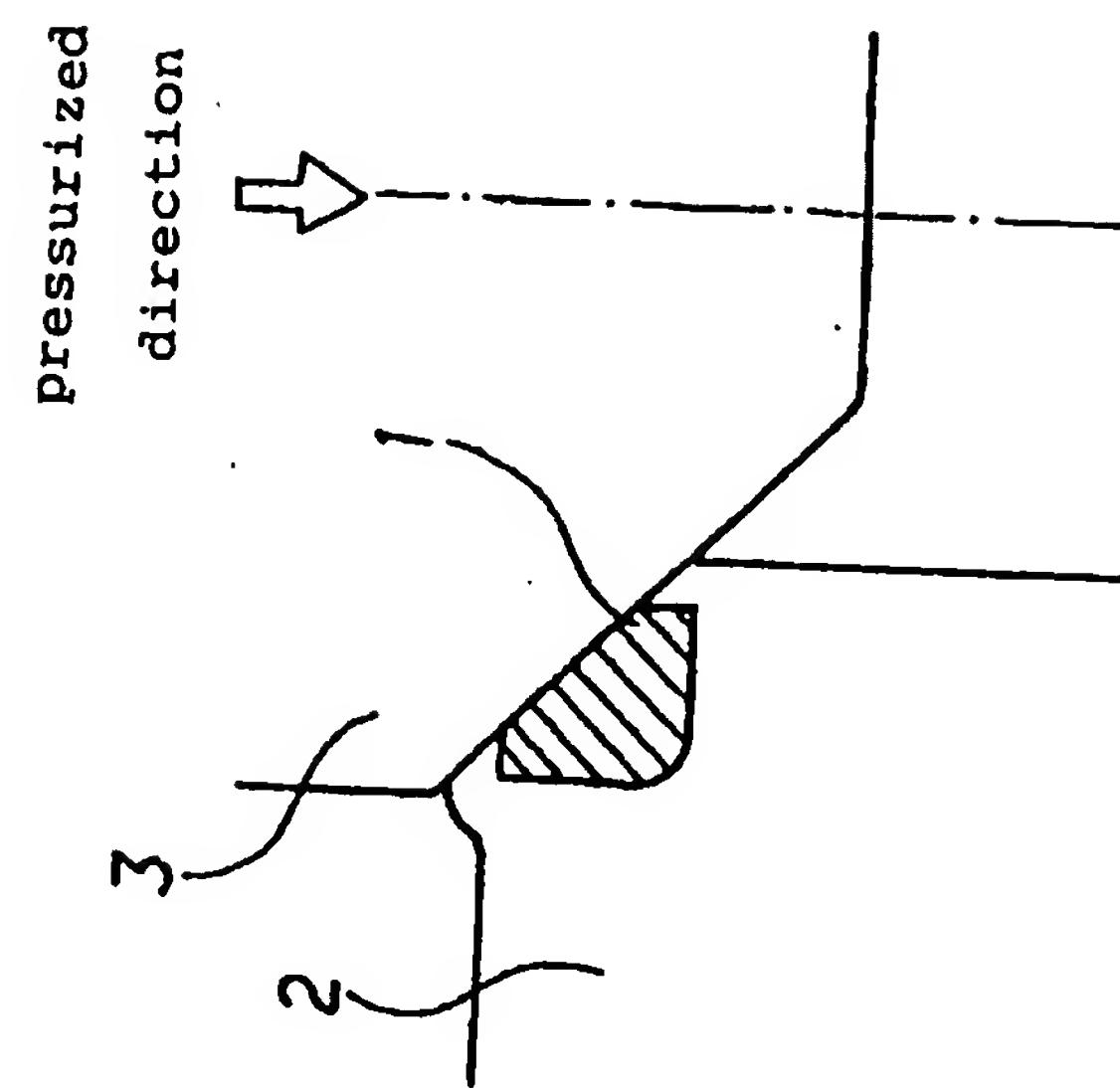
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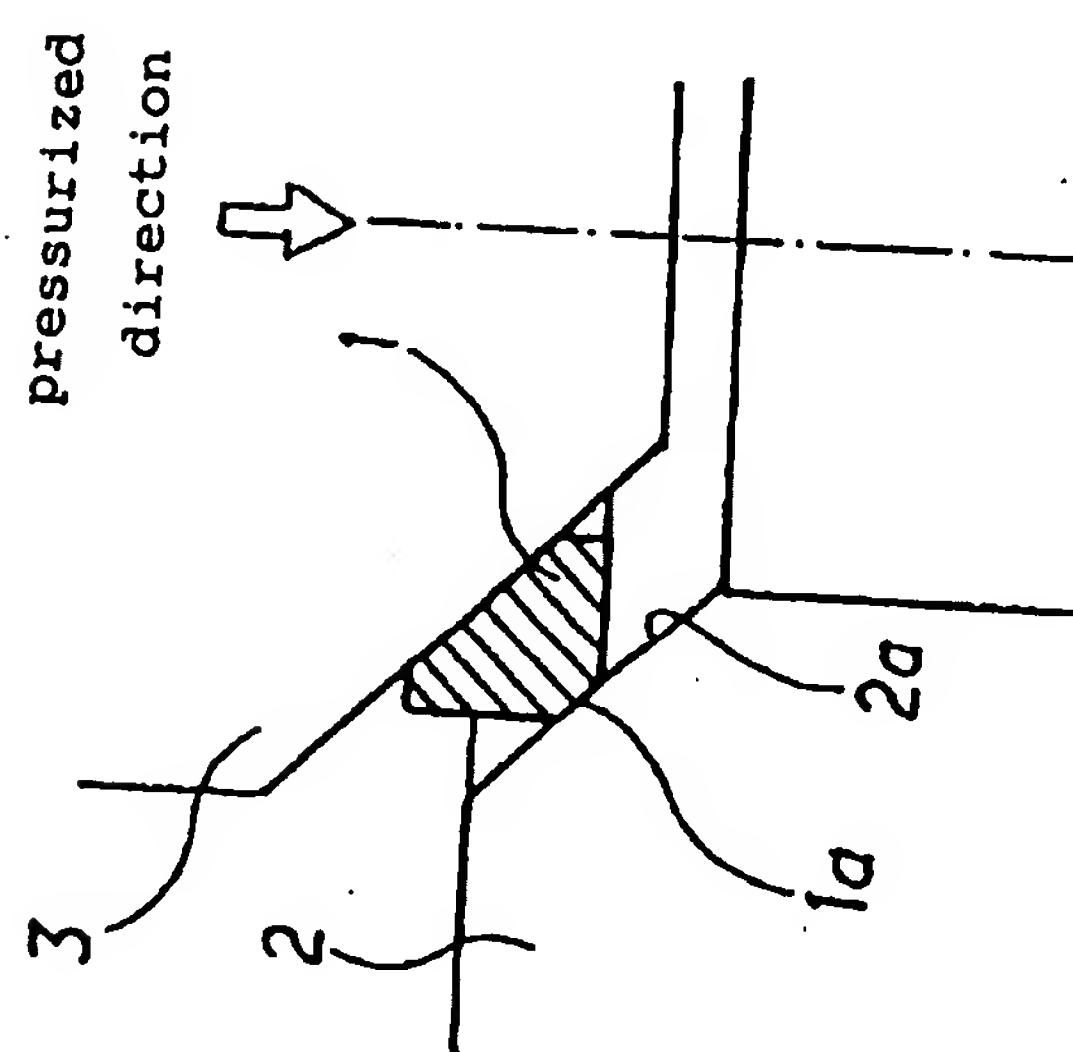
FIG. 1

1/2

(b)



(a)



z/z

FIG. 2

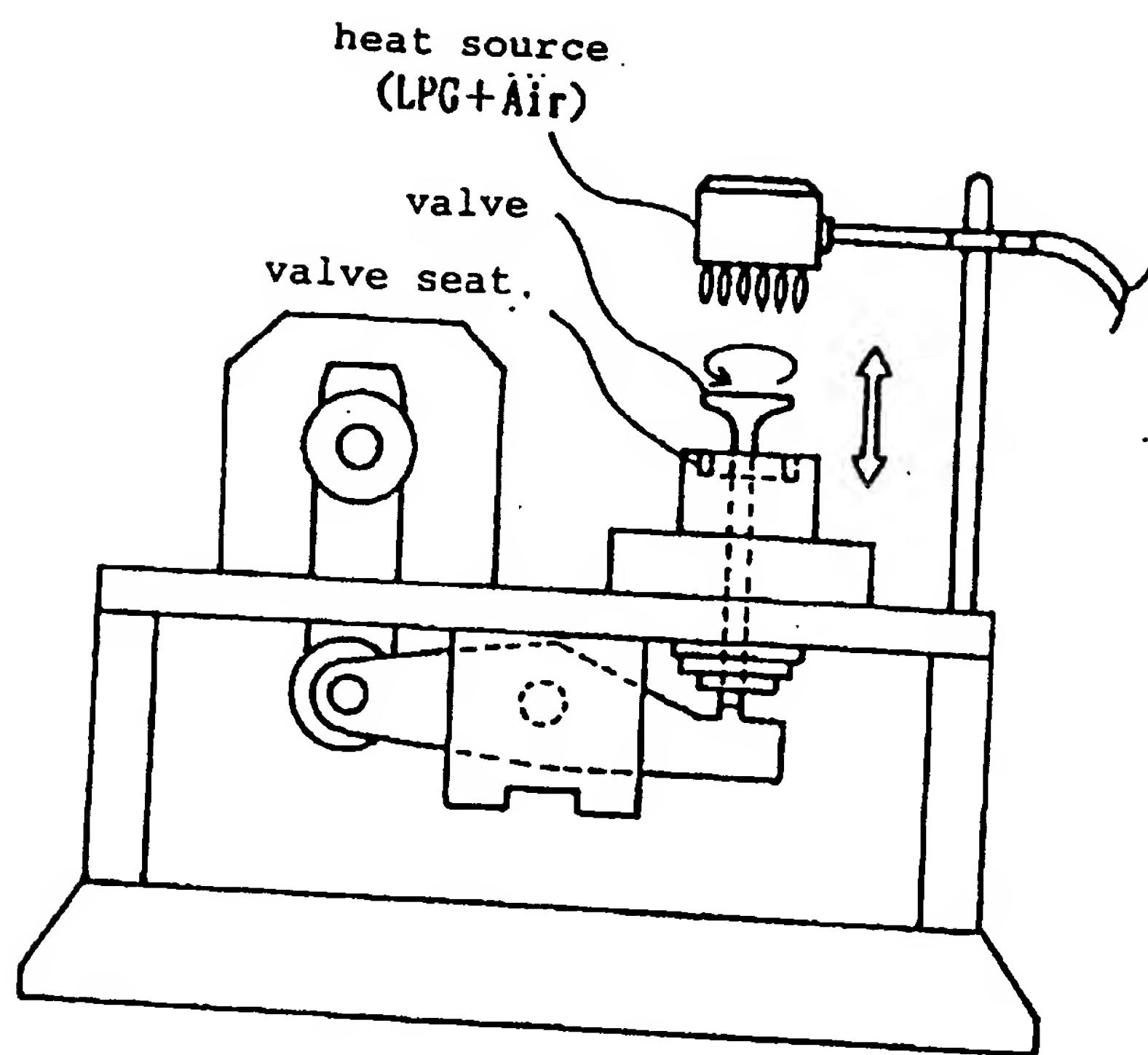
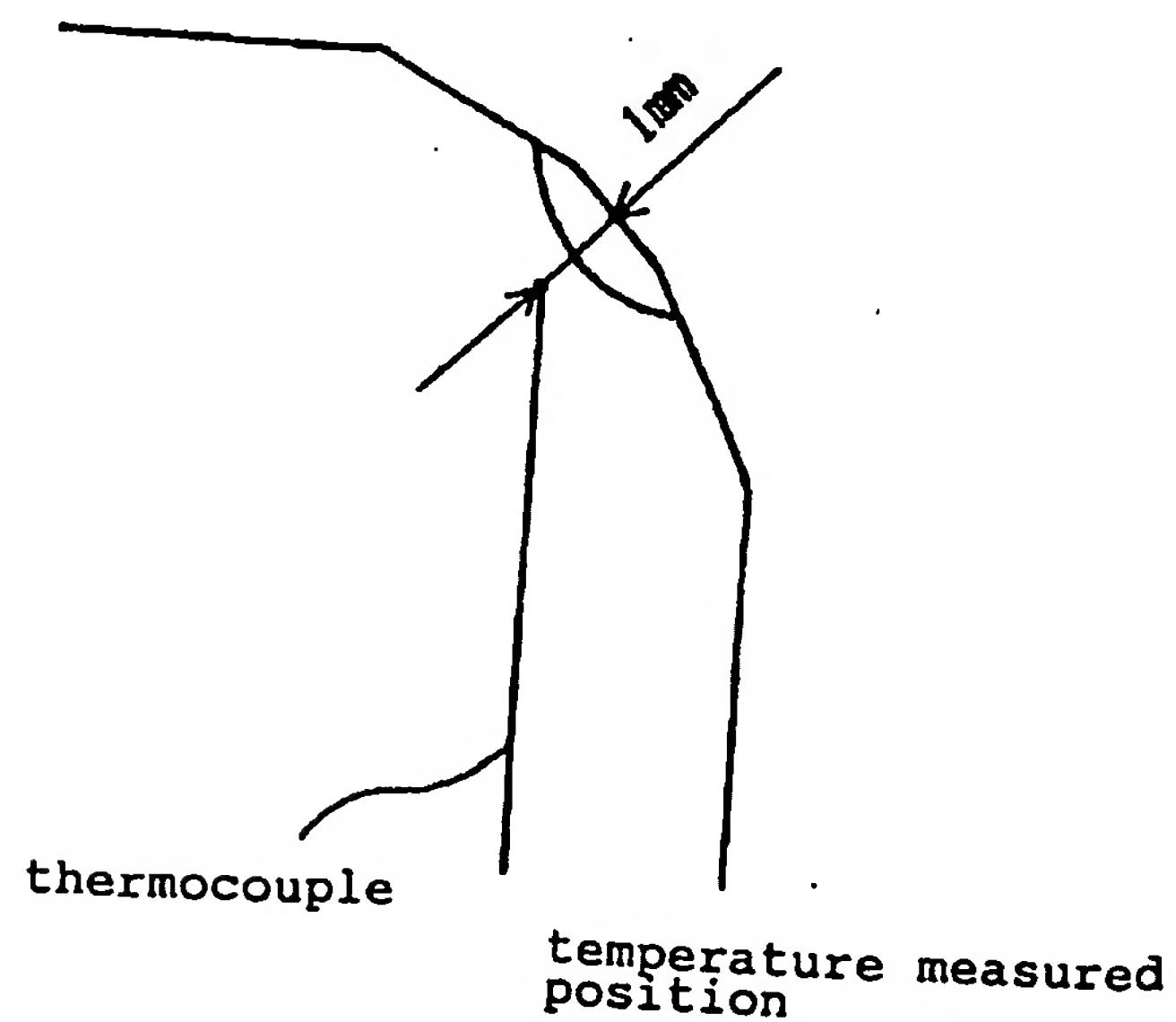


FIG. 3



A joined type valve seat

The present invention relates to a valve seat used in an internal combustion engine, in particular a valve seat joined into the valve head of the engine.

In commonly accepted technique, a valve seat was force-fitted into the cylinder head of an internal combustion engine and served to fulfil sealing of combustion gas as well as cooling of the valve. On the other hand, recently, in view of speed-up and weight reduction of cars, a multi-valve structure of the engine has been developed so that each cylinder has a plurality of suction and exhaust ports disposed close together. On such a recent tendency, in order to reduce intervals between the valves, to ensure a degree of freedom in design such as enlarging the diameters of the suction and exhaust ports, to improve heat removal from the valve and the valve seat so as to relieve thermal load, and so forth, a joined type valve seat which is joined into the cylinder head has been proposed.

In prior art, sintered alloys used for the valve seat have been known, and for example, there is seen Japanese Patent Laid-open Gazette No.25959/1984 of which the entire disclosure is expressly incorporated herein by reference, which discloses a sintered alloy used for valve seats. This sintered alloy contains a good deal of C, Ni, Cr, Mo, Co, and also hard particles dispersed in the matrix structure, the said hard particles being consisted of C-Cr-W-Co-Fe powder and Fe-Mo powder. Also, this sintered alloy includes continuous pores infiltrated with copper alloy, and has been used for valve seats superior in strength, rigidity and abrasion resistance.

But, where a joined type valve seat is made of such conventional sintered alloy used for the valve seat, there may be caused cracks in the valve seat when the valve seat is joined or when the engine is driven. Such cracks lower the sealing performance of the valve seat. And this leads to a hindrance

in mass production. The occurrence of cracks, compared with the force-fitted type valve seat, is attributable to relatively small form of the joined type valve seat, and is caused by exceeding its endurable limit under stresses at resistance welding for joining or at the engine driving.

To solve these problems, there is seen, for example, Japanese Patent Laid-open Gazette No.189628/1995 of which the entire disclosure is expressly incorporated herein by reference, which discloses a joined type valve seat which is made of a Cu-base alloy or an austenite-base iron series alloy, said valve seat being joined into the cylinder head by a resistance welding.

Although in this valve seat there may be no cracks caused in the joining process or at the engine driving, it includes some expensive alloy elements, which brings economic disadvantage and also inferiority in strength, rigidity and abrasion resistance.

An object of the invention is to solve the above mentioned drawbacks and therefore to provide an improved valve seat superior in strength, rigidity and abrasion resistance so that there can not be caused any cracks in the joining process or at the engine driving.

We thought out that the cracks which were caused at the resistance welding and at the engine driving, would occur from difference in expansion between the valve seat and the cylinder head generated in heating and cooling at the engine driving or in the joining process at the resistance welding due to difference in coefficient of thermal expansion between a material of the cylinder head and a material of the valve seat. Thus we, according to our investigations and efforts, found out that it was needed to form a layer coated on surfaces of the valve seat contacting with the cylinder head to thereby prevent the joined type valve seat from occurring cracks therein, said layer having coefficient of thermal expansion of an intermediate value between coefficient of thermal expansion of the valve seat and that of the cylinder head. Also, we found a novel knowledge that, when the valve seat coated with such layer on surfaces contacting with the cylinder head was joined into Al alloy cylinder head by a resistance welding, kinds of intermetallic compounds with Al alloy were

formed on the joined surfaces to thereby improve the joining strength and reduce the difference in thermal expansion between the cylinder head and the valve seat, which hindered occurrence of cracks.

The present invention is based on the above mentioned knowledge and outcomes.

Accordingly, the present invention provides a joined type valve seat to be joined into Al alloy cylinder head of an internal combustion engine by means of a resistance welding, wherein said valve seat is made of Fe-base sintered alloy and has pure metal layer or alloy layer coated on at least its surfaces contacting with the cylinder head, said pure metal layer or alloy layer being of thickness of $10\mu\text{m}$ or less and having coefficient of thermal expansion of $15 \times 10^{-6} - 25 \times 10^{-6}$ (1/K). Also, said valve seat may be made of Cu-infiltrated Fe-base sintered alloy or Fe-base sintered alloy with pores sealed with copper. Furthermore, said valve seat may be made of cast iron or cast steel or Ni-base alloy ingot and continuous casting material.

Also, the present invention provides a joined type valve seat to be joined into Al alloy cylinder head of an internal combustion engine by means of a resistance welding, wherein said valve seat is characterized by being made of Cu-base alloy and has pure metal layer or alloy layer coated on at least its surfaces contacting with the cylinder head, said pure metal layer or alloy layer being of thickness of $10\mu\text{m}$ or less and having coefficient of thermal expansion of $18 \times 10^{-6} - 27 \times 10^{-6}$ (1/K).

Further, the present invention provides a joined type valve seat to be joined into Al alloy cylinder head of an internal combustion engine by means of a resistance welding, wherein said valve seat is characterized by being made of ceramics and has pure metal layer or alloy layer coated on at least its surfaces contacting with the cylinder head, said pure metal layer or alloy layer being of thickness of $10\mu\text{m}$ or less and having coefficient of thermal expansion of $10 \times 10^{-6} - 20 \times 10^{-6}$ (1/K).

Embodiments of the invention are described below with reference to the accompanying diagrams in which:

Figure 1 is a schematic view showing a joining situation for joining the valve seat into the cylinder head by a resistance welding;

Figure 2 is an approximate schematic view of a rig tester; and,

○ Figure 3 is a schematic view showing a temperature-measured position of a sample in a rig tester.

The invention and advantageous details will now be explained more fully with reference to exemplary embodiments.

The joined type valve seat of the present invention is formed by working a material into a determined form and joined into Al alloy cylinder head by a resistance welding. Otherwise, as the joining method, a resistance welding is desirable, but other methods such as a friction welding or an electronic beam welding could be used.

The valve seat of the invention has a coating layer of thickness of $10\mu\text{m}$ or less formed on at least its surfaces contacting with the cylinder head. It will be understood that said layer could be coated on surfaces other than the surfaces contacting with the cylinder head.

When the valve seat having the layer coated thereon is joined into Al alloy cylinder head by a resistance welding, kinds of intermetallic compounds combined with the Al alloy are formed on the joined surfaces. This leads to an increase in the joining strength and reduces difference in thermal expansion between the cylinder head and the valve seat to thereby prevent occurrence of cracks.

If the thickness of the layer exceeds $10\mu\text{m}$, there will be single layer of coating material besides the intermetallic compound layer on the joining portions, which results in uneven structure of the joining portions. Owing to the existence of such single layer of coating material, plastic flow layer is formed by an insert pressure at the resistance welding. This leads to lowering in strength, and accordingly cracks will easily occur at the welding for the joining or at the engine driving. Therefore, the coating layer will have its upper limit of thickness of $10\mu\text{m}$.

The coating layer formed on surfaces of the valve seat will be pure metal layer or alloy layer having coefficient of thermal expansion corresponding to a material of the valve seat.

Such pure metal layer may preferably be of Cu, Ni, or Ag, and such alloy layer may preferably be of Cu, Ni, Ag-base alloy.

The coating layer will desirably be formed by plating, coating, vacuum evaporation, etc.

Where the valve seat is made of Fe-base sintered alloy, the coating layer will preferably be pure metal layer or alloy layer having coefficient of thermal expansion of 15×10^{-6} - 25×10^{-6} (1/K).

If the coefficient of thermal expansion of the coating layer is below 15×10^{-6} (1/K), the difference in coefficient of thermal expansion between the layer and the cylinder head will be big, and also if it exceeds 25×10^{-6} (1/K), the difference in coefficient of thermal expansion between the layer and the valve seat will be big, so that cracks may occur at the resistance welding or at the engine driving. Therefore, where the valve seat is made of Fe-base sintered alloy, the coefficient of thermal expansion of the coating layer will be in the range of from 15×10^{-6} to 25×10^{-6} (1/K).

The material of the valve seat, instead of Fe-base sintered alloy, may be of Cu-infiltrated Fe-base sintered alloy or Fe-base sintered alloy with pores sealed with copper, or of cast iron or cast steel or Ni-base alloy ingot material. In these cases, the coating layer having the same range of coefficient of thermal expansion will preferably be usable.

Any Fe-base sintered alloy usable for the valve seat, among usually known Fe-base sintered alloys used for valve seats, can preferably be used. In particular, Fe-base sintered alloy is preferable which contains C, Ni, Cr, and Co, and hard particles consisting of C-Cr-W-Co-Fe particles dispersed in the matrix structure, and also Fe-base sintered alloy is preferable which contains C, Ni, Cr, Mo and Co, and hard particles consisting of C-Cr-W-Co-Fe particles and Fe-Mo particles dispersed in the matrix structure. Furthermore, Fe-base sintered alloy is preferable which is of high speed steel series, stainless steel series or low alloy series containing 0.5 - 8% of at least one of Ni and Mo.

Also, Cu-infiltrated Fe-base sintered alloy can be obtained by the following processes; namely, powder as raw material is filled into a metal mould and then press-formed by a forming press. After that, the formed powder body is sintered, and the sintered body together with copper alloy used for infiltration is heated

to a temperature exceeding the melting point of the copper alloy to infiltrate pores with the copper alloy. Furthermore, instead of such infiltration treatment, copper powder will primarily be mixed into the raw material powder, and the copper powder will be liquefied at the sintering thereby to seal pores with copper. Also, in the Cu-infiltration treatment, Cu layer of thickness of $10\mu\text{m}$ or less will be kept on surfaces of the sintered body thereby to eliminate the formation of the copper layer.

In the present invention, sintered alloy is not always used, but an ingot and continuous casting material may be employed. As such ingot and continuous casting materials, cast iron, cast steel and Ni-base alloy will be preferably used. As preferable cast iron used for the valve seat, FCD600 spheroidal graphite cast iron and flake graphite alloy cast iron containing Cr, B and others can be found. Also, as preferable cast steel, there will be seen high Ni cast steel containing a considerable amount of Ni, high Cr cast steel and Cr-Si series cast steel. Ni-base alloy will preferably be of NCF(JIS G4901 - 4902) series, Ni-Cr series and so forth.

Where the valve seat is made of Cu-base alloy, the layer is preferably pure metal layer or alloy layer having coefficient of thermal expansion of $18 \times 10^{-6} - 27 \times 10^{-6}$ (1/K).

When the valve seat is made of Cu-base alloy, metal powder sintered method, ingot and continuous casting material method or machining from rolled material will be employed.

Where the valve seat is made of Cu-base alloy, if the coefficient of thermal expansion of the coating layer is below 18×10^{-6} (1/K), the difference in coefficient of thermal expansion between the layer and the cylinder head will be big, and also if it exceeds 27×10^{-6} (1/K), the difference in coefficient of thermal expansion between the layer and the valve seat will be big, so that cracks may occur at the resistance welding or at the engine driving. Therefore, the coefficient of thermal expansion of the coating layer will be in the range of from 18×10^{-6} to 27×10^{-6} (1/K).

Cu-base alloys which will be usable for the valve seat of the invention are preferably Cu-Ni-Si alloy, Cu-Be alloy and Cu-Cr alloy.

Where the valve seat is made of ceramics, the coating layer

is preferably pure metal layer or alloy layer having coefficient of thermal expansion of 10×10^{-6} - 20×10^{-6} (1/K).

Ceramics which will be usable for the valve seat of the invention are preferably Si_3N_4 , Al_2O_3 , and SiC .

When the valve seat is made of ceramics, a metal powder sintering method will be preferably employed, in which powder of Si_3N_4 , Al_2O_3 and SiC together with a sintering auxiliary agent (for example, polyvinyl alcohol, methyl cellulose) are mixed and formed, and thereafter sintered.

Where the valve seat is made of ceramics, if the coefficient of thermal expansion of the coating layer is below 10×10^{-6} (1/K), the difference in coefficient of thermal expansion between the layer and the cylinder head will be big, and also if it exceeds 20×10^{-6} (1/K), the difference in coefficient of thermal expansion between the layer and the valve seat will be big, so that cracks may occur at the resistance welding or at the engine driving. Therefore, the coefficient of thermal expansion of the coating layer will be in the range of from 10×10^{-6} to 20×10^{-6} (1/K).

Embodiments of manufacture of materials for the joined type valve seat will now be described.

(Embodiment 1)

(Samples No.1 and No.2)

Primary powder (raw material) which consisted of C powder, Co powder, Ni powder, C-Co-W-Cr-Fe alloy powder and atomized pure iron powder, was combined with zinc stearate and mixed together. This mixed powder was press-formed and thereafter sintered in a reduction atmosphere, from which Fe-base sintered alloy was obtained. The composition of the obtained sintered alloy consisted of, by weight, C:1.2%, Ni:2.0%, Cr:6.5%, W:2.0%, Co:7.0% and the remainder being inevitable impurities and Fe. This sintered alloy contained hard particles dispersed in the matrix structure. Such sintered alloy was worked to joined type valve seats.

On sample No.1, Cu layer having $3\mu\text{m}$ thickness was coated on its surfaces contacting with the cylinder head by plating. On sample No.2, no coating layer was applied thereon.

(Samples No.3 and No.4)

Primary powder which consisted of C powder and high speed steel powder, was combined with zinc stearate and mixed together. This mixed powder was press-formed and then sintered in a reduction

atmosphere. Then, the sintered body was infiltrated with copper, from which Cu-infiltrated Fe-base sintered alloy was obtained. The composition of the obtained sintered alloy consisted of, by weight, C:1.0%, Cr:2.0%, Mo:2.5%, W:3.0%, V:3.0%, Cu:15.0% and the remainder being impurities and Fe. This sintered alloy contained fine carbide particles dispersed in the matrix structure. Such sintered alloy was worked to joined type valve seats.

On sample No.3, Cu layer having 5 μ m thickness was coated on its surfaces by plating, and on sample No.4, Cu layer having 20 μ m thickness was coated on its surfaces.

(Samples No.5 and No.6)

Primary powder which consisted of C powder, Cr-Fe alloy powder, Fe-Mo powder and pure iron powder, was combined with zinc stearate and mixed together. This mixed powder was press-formed and sintered in a reduction atmosphere, from which Fe-base sintered alloy was obtained. The composition of the obtained sintered alloy consisted of, by weight, C:2.0%, Cr:12.0%, Mo:1.0% and remainder being impurities and Fe. This sintered alloy contained Cr carbide precipitated in the matrix structure. Such sintered alloy was worked to joined type valve seats. On sample No.5, Cu layer having 4 μ m thickness was coated by plating, and on sample No.6, Ag layer having 3 μ m thickness was coated by plating.

(Samples No.7 and No.8)

High Ni cast steel which consisted of, by weight, C:2.5%, Si:2.0%, Mn:1.0%, Ni:20.0%, Cr:5.0% and the balance Fe, was obtained through an electric melting furnace - casting process. The obtained material was worked to joined type valve seats. On sample No.7, Ni layer having 5 μ m thickness was coated by plating, and on sample No.8, Cu layer having 18 μ m thickness was coated by plating.

(Samples No.9 and No.10)

Spheroidal graphite cast iron which consisted of, by weight, C:3.6%, Si:2.0%, Mn:0.3%, Cu:1.0% and the balance Fe, was obtained through a high frequency melting furnace - casting process. The obtained material was worked to joined type valve seats. On sample

No.9, Cu layer having $1\mu\text{m}$ thickness was coated by plating, and on sample No.10, Ni layer having $2\mu\text{m}$ thickness was coated by plating.

(Samples No.11 - No.14)

Primary powder which consisted of C powder, Co powder, Ni powder, C-Co-W-Cr-Fe alloy powder and atomized pure iron powder, was combined with zinc stearate and mixed together. This mixed powder was press-formed and thereafter sintered in a reduction atmosphere. Then the sintered body was infiltrated with copper used for infiltration disposed thereon and subjected to a heat treatment (quenching, tempering), from which Fe-base sintered alloy with sintering pores infiltrated with copper alloy was obtained. The composition of the obtained sintered alloy consisted of, by weight, C:1.3%, Ni:2.0%, Cr:7.0%, W:2.2%, Co: 7.0%, Cu:15.0% and the remainder being impurities and Fe. This sintered alloy contained hard particles dispersed in the matrix structure. Such sintered alloy was worked to joined type valve seats. On sample NO.11, Cu layer having $2\mu\text{m}$ thickness was coated, and on sample No.13, Ni layer having $30\mu\text{m}$ thickness was coated, and on sample No.14, Ag layer having $6\mu\text{m}$ thickness was coated, respectively by plating. But on sample No.12, no layer was coated thereon.

As for kinds of the materials for the joined type valve seats, their coefficients of thermal expansion, kinds of the layers coated on the valve seat materials, and coefficients of thermal expansion of the layers, these are shown in Table 1.

In the next step, these joined type valve seats were joined into the cylinder head made of Al alloy (AC4C) by a resistance welding. Figure 1 shows the joining step by a resistance welding.

As shown in Figure 1 (a), the valve seat 1 is set in such a way that its projected portion 1a abuts on a slant surface 2a of the cylinder head 2, and a pressure is applied in direction of the shown arrow on the valve seat 1 mounted on the slant surface 2a by an electrode 3. After that, an electric current is applied on them. After the contacting surfaces between the cylinder head 2 and the valve seat 1 and their proximity are heated to the melting point or a temperature adjacent thereto, the electric current is cut off. Then the cylinder head 2 of which hardness is lower

than that of the valve seat is plastically deformed, and as shown in Figure 1(b), the valve seat 1 is joined into the cylinder head 2 so as to be imbedded therein.

After the joining process, any possible cracks in the valve seats were searched. The results are represented in Table 1.

Also, as for the joined type valve seats which were in the same conditions as they were joined into the cylinder head, the valve seats were tested by a rig tester at the same temperature as the one in an endurance test with a real machine and under the conditions that the valve seats were knocked with the valve, in order to search any occurrence of cracks in the valve seats.

The test conditions are described below;

Test temperature: 400 °C (measured position: shown in Fig.3)

Driving time: 30 hours

Cam rotary speed: 3000 rpm

Valve rotary speed: 10 rpm

Lift value: 7 mm

Load on seat: 89 kg

The results are represented in Table 1.

(Embodiment 2)

Primary powder which consisted of Cu-Be alloy powder or Cu-Cr alloy powder or Cu-Ni-Si alloy powder was mixed with a sintering auxiliary agent and formed to a material used for the valve seat through a press-forming, sintering and heat treatment process. Also, Si_3N_4 or Al_2O_3 powder as ceramics was mixed with a sintering auxiliary agent and formed to a material for the valve seat through a press-forming, sintering and heat treatment process. These materials were worked to joined type valve seats, and a coating layer shown in Table 2 was coated on their surfaces contacting with the cylinder head. Some samples having no coating layer thereon were represented as compared ones.

The joined type valve seats having a coating layer thereon shown in Table 2 (as compared samples, samples having no coating layer are included therein) were joined into Al alloy cylinder head by a resistance welding in the same way as the one in the embodiment 1, and any occurrence of cracks in the valve seats were searched. The results are represented in Table 2.

Also, similarly to embodiment 1, the valve seats were tested by a rig tester at the same temperature as the one in an endurance

(Table 1)

SAMPLE NO.	VALVE SEAT		COATING LAYER		OCCURRENCE OF CRACKS		REMARKS
	MATERIALS	Coefficient of thermal expansion ($1/K$)	Coating materials	Thickness (μm)	Coefficient of thermal expansion ($1/K$)	At joining by resist welding	
1	C-Co-Ni-W-Cr series Fe-base sintered alloy	10.6×10^{-6}	Cu	3	18.3×10^{-6}	Nil	Nil Sample of invention
2		=	=	-	-	Being	— Compared sample
3	high speed steel series sintered alloy (Cu-infiltrated)	13.0×10^{-6}	Cu	5	18.3×10^{-6}	Nil	Nil Sample of invention
4		=	=	-	-	Being	— Compared sample
5	liquid-phase sintered Fe-base sintered alloy	12.0×10^{-6}	Cu	4	18.3×10^{-6}	Nil	Nil Sample of invention
6		=	=	-	-	Being	— Compared sample
7	high Ni cast steel	15.0×10^{-6}	Ni	5	15.5×10^{-6}	Nil	Nil Sample of invention
8		=	=	-	-	Being	— Compared sample
9	spheroidal graphite cast iron	11.0×10^{-6}	Cu	1	18.3×10^{-6}	Nil	Nil Sample of invention
10		=	=	-	-	Being	— Compared sample
11	C-Ni-Cr-Co-W-Cu series Fe-base sintered alloy (Cu-infiltrated)	12.0×10^{-6}	Cu	2	18.3×10^{-6}	Nil	Nil Sample of invention
12		=	=	-	-	Being	— Compared sample
13		Ni	30	15.5×10^{-6}	Nil	Being	Compared sample
14	Ag	6	20.6×10^{-6}	Nil	Nil	Nil Sample of invention	Sample of invention

Note) Coefficient of thermal expansion ($1/K$) of cylinder head made of Al alloy (AC4C) : 26.5×10^{-6}

(Table 2)

SAMPLE NO.	VALVE SEAT		COATING LAYER		OCCURRENCE OF CRACKS		REMARKS
	MATERIALS	Coefficient of thermal expansion ($1/K$)	Coating materials	Thickness (μm)	Coefficient of thermal expansion ($1/K$)	At joining by resist-welding	
1 5	Cu-Be alloy	10.6×10^{-6}	Cu	3	18.3×10^{-6}	Nil	Sample of invention
1 6		—	—	—	—	Nil	Compared sample
1 7	Cu-Cr alloy	10.5×10^{-6}	Cu	5	18.3×10^{-6}	Nil	Sample of invention
1 8		Ag	25		20.6×10^{-6}	Nil	Being
1 9	Cu-Ni-Si alloy	16.0×10^{-6}	Cu	2	18.3×10^{-6}	Nil	Sample of invention
2 0			Cu	8	18.3×10^{-6}	Nil	Sample of invention
2 1	ceramics(Si ₃ N ₄)	3.2×10^{-6}	Ni	3	15.5×10^{-6}	Nil	Sample of invention
2 2			—	—	—	Being	—
2 3	ceramics(Al ₂ O ₃)	8.0×10^{-6}	Cu	5	18.3×10^{-6}	Nil	Sample of invention
2 4		Ag	30		20.6×10^{-6}	Nil	Being
							Compared sample

Note) Coefficient of thermal expansion ($1/K$) of cylinder head made of Al alloy (AC4C) : 26.5×10^{-6}

test with a real machine and under the conditions in which the valve seat was knocked with the valve, thereby to search any occurrence of cracks in the valve seats. Table 2 represents the test results.

In the range of the present invention, no cracks were caused by thermal stresses in the joining process, and in rig test under the same conditions as those in a real machine, there were seen no cracks.

On the other hand, concerning the joined type valve seats of samples no.4, No.8, No.13, No.18, No.21, No.24 as compared samples, these valve seats had a coating layer which was not in the range of the invention. As for these valve seats, although there were no cracks in the joining process by a resistance welding, there were caused cracks in the rig tests. Furthermore, in the joined type valve seats of samples No.2, No.12, No.16 and No.22 as compared samples, there were caused cracks in the joining process by a resistance welding.

According to the present invention, there are not seen any cracks caused both at the joining by a resistance welding and at the engine driving, whereby a high sealing performance can be maintained.

Having now fully described the present invention, it will be understood for one of ordinary skill in the art that many changes and modifications can be made without departing from the spirit or scope of the invention as set forth herein.

The entire disclosure of Japanese Patent Application No.133577/1996 filed on May 28, 1996 including specification, claims, drawings and summary are incorporated here by reference in its entirety.

CLAIMS :

1. A joined type valve seat joined into Al alloy cylinder head of an internal combustion engine by means of a resistance welding, wherein said valve seat is made of Fe-base sintered alloy and has pure metal layer or alloy layer coated on at least its surfaces contacting with the cylinder head, said pure metal layer or alloy layer being of thickness of $10\mu\text{m}$ or less and having coefficient of thermal expansion of $15 \times 10^{-6} - 25 \times 10^{-6}$ (1/K).
2. The joined type valve seat set forth in claim 1, wherein said valve seat is made of Cu-infiltrated Fe-base sintered alloy or Fe-base sintered alloy with pores sealed with copper.
3. The joined type valve seat set forth in claim 1, wherein said valve seat is made of cast iron or cast steel or Ni-base alloy ingot material.
4. A joined type valve seat joined into Al alloy cylinder head of an internal combustion engine by means of a resistance welding, wherein said valve seat is made of Cu-base alloy and has pure metal layer or alloy layer coated on at least its surfaces contacting with the cylinder head, said pure metal layer or alloy layer being of thickness of $10\mu\text{m}$ or less and having coefficient of thermal expansion of $18 \times 10^{-6} - 27 \times 10^{-6}$ (1/K).
5. A joined type valve seat joined into Al alloy cylinder head of an internal combustion engine by means of a resistance welding, wherein said valve seat is made of ceramics and has pure metal layer or alloy layer coated on at least its surfaces contacting with the cylinder head, said pure metal layer or alloy layer being of thickness of $10\mu\text{m}$ or less and having coefficient of thermal expansion of $10 \times 10^{-6} - 20 \times 10^{-6}$ (1/K).
6. A joined type valve seat substantially as described herein with reference to the accompanying drawings.



The Patent Office

i5

Application No: GB 9707409.0
Claims searched: 1-3

Examiner: Tim James
Date of search: 14 July 1997

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F1B (B2Q13); F2V (VG3, VP43, VP45, VX1)

Int Cl (Ed.6): F01L (3/22)

Other: On-line: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, P	EP 0743428 A1	(Yamaha) see claims 4-9 and page 5 lines 32-34	1 and 2 at least
X, P	EP 0723069 A1	(Yamaha) see column 10 lines 37-50 and column 12 lines 28-43	1 and 2 at least
A	US 5586530	(Yamaha) see column 8 lines 51-64	—

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.